Expert Report

# Settled Dust; What Is It and Is It Relevant to Assessment Of Asbestos Inhalation Risk?

by

Morton Corn, Ph.D., CSP
Morton Corn & Associates, Inc.
3208 Bennett Point Road
Queenstown, Maryland 21658-1126

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## I. Qualifications

I am a Professor Emeritus of Environmental Health Engineering in the Bloomberg School of Public Health of the Johns Hopkins University and President, Morton Corn and Associates, Inc., a consulting firm that works out of my home in Queenstown, Maryland. Environmental health engineering is a discipline concerned with the evaluation of air, water, soil and materials in our environment and the interventions to improve them if they are found to be unhealthy or to pose a human health risk. I received a Bachelor's degree in Chemical Engineering from Cooper Union School of Engineering in 1955, a Master of Science degree in Industrial Hygiene and Sanitary Engineering from Harvard University in 1956, and a Doctor of Philosophy degree in Industrial Hygiene and Sanitary Engineering from Harvard University in 1961. The subject of my doctoral dissertation was the adhesion and re-entrainment of particles from surfaces.

From October 1975 until January 1977, I served as Assistant Secretary of Labor for Occupational Safety and Health. I have provided consultation services to many private and governmental organizations, including the United States Atomic Energy Commission, the United States Public Health Service, the United States Bureau of Mines, the World Health Organization, the United States Department of Energy, the United States General Services Administration, the United States Environmental Protection Agency (EPA), the National Institute of Environmental Health Sciences, Harvard University School of Public Health, the American Petroleum Institute, Pennsylvania State University, and the Brookings Institution. As a consultant to the United States Environmental Protection Agency (EPA), I served on its Science Advisory Board (SAB) from 1977 to 1984. The SAB reviewed EPA's Health Assessment document for asbestos.

Included in the awards I have received is the Cummings Award, which is given once a year by the American Industrial Hygiene Association for outstanding contributions in the field of industrial hygiene. My Cummings Award Lecture was on Asbestos and Public Health. (Corn, M., "Asbestos and Disease: An Industrial Hygienist's Perspective," Am. Ind. Hyg. Assoc. J., 47(9), 515-23 (1986)). I have published more than one hundred peer-reviewed articles, fifteen or more chapters in books, and edited three books. In 1994, I received the Smyth Award of the American Academy of Industrial Hygiene, an annual award for outstanding contributions to industrial hygiene. In 2000, I was elected a Director on the Board of the American Industrial Hygiene Association and served for three years. In June 2001, I received the Meritorious Achievement Award of the American Conference of Governmental Industrial Hygienists. It is presented once a year for "outstanding, long-term contribution to the field of occupational health and industrial hygiene." In 2003, I received a certificate of appreciation from the National Academy of Sciences for service on the committee which addressed "Risk Assessment in the Federal Government: Managing the Process."

I have measured asbestos and other dusts-in-air in glass, steel, and insulation manufacturing facilities, for examples, during the 1950's, 1960's, 1970's, and have designed ventilation systems to capture potentially toxic dusts and gases from processing

operations. I taught graduate courses at Johns Hopkins University and the University of Pittsburgh in the subject areas of industrial hygiene, air pollution, industrial ventilation, aerosol technology and risk assessment.

I have conducted extensive research and studies on airborne asbestos concentrations in buildings as it relates to occupants and to workers who work with or near asbestos-containing materials and have published many of these studies. (See e.g., Mlynarek, S., Corn, M., and Blake, C., "Asbestos Exposure of Building Maintenance Personnel, "Reg. Tox. & Pharm. 23(3) 213-224 (1996); Corn, M., et al., "Asbestos Exposures of Building Maintenance Personnel, "Appl. Occup. Env. Hyg. 9(11), 845-852 (1994); Corn, M., "Airborne Concentrations of Asbestos in Non-Occupational Environments," Ann. Of Occup. Hyg. 38(4), 495-502 (1994); M. Corn, et al., "Exposure to Airborne Asbestos in Buildings," Reg. Tox. & Pharm. 16, 93-107 (1992); M. Corn, et al., "Airborne Concentrations of Asbestos in 71 School Buildings," Reg. Tox. & Pharm. 13, 99-114 (1991); Corn, M., et al., "Asbestos: Scientific Developments and Implications for Public Policy," Science 247, 294-301 (1990); Esmen, N.A. and Corn, M.; "Airborne Fiber Concentrations During Splitting Open and Boxing Bags of Asbestos," Tox. and Ind. Hlth. 14(6), 843-856 (1998). I have participated in numerous United States and international scientific, industrial hygiene, and public health conferences. For example, I participated in the Workshop on the Biological Effects of Fibers organized by the International Agency for Research on Cancer held in Lyon, France in June 1977, was an invited speaker and session chairman at the International Conference on Biological Effects of Man-made Mineral Fibers held in Copenhagen, Denmark in 1982, and have been invited by the federal government to comment on regulatory rule-makings concerning asbestos.

In addition I have conducted research and field investigations of silica dust (See Villnave, J., Corn, M., Francis, M. and T. Hall: Regulatory Implications of Airborne Respirable Free Silica Variablility in Underground Coal Mines. Am. Ind. Hyg. Assoc. J. 52: 107-112 (1991): cotton dust (See Corn M.: Methods to Assess Airborne Concentrations of Cotton Dust. Am. J. Industr. Med. 47, 497-504 (1986); Hammad, YY and M. Corn: Hygienic Assessment of Airborne Cotton Dust in a Textile Manufacturing Facility. Am. Ind. Hyg. Assoc. J. 32: 662 (1971), and fibrous glass dust, (See Corn M., Esmen, N.A. and Y.Y. Hammad, et al.: Exposure of Employees to Man-Made Mineral Fibers: Mineral Wool Production. Environ. Res. 15: 267-277 (1978), among other potentially toxic agents.

My Curriculum Vitae is attached as Exhibit A. My fee for professional consulting services, including expert consultation and testimony in litigation, is $4000 per day or $500 per hour. I have been accepted as an expert in various federal and state courts to testify in asbestos-in-buildings cases and in other litigation.

## II. Scope

I have been asked by Counsel for W.R. Grace & Co. to address the subject of whether settled dust has any relevance as a measure of risk and the historical utilization of settled dust in outdoor air pollution, industrial hygiene studies and its relatively recent usage to assess alleged asbestos "contamination" in buildings. Settled dust has been used in the

past to determine rates of dustfall when heavily polluted cities were subject to smoke pollution, mainly soot. It has also been used to determine the weight of dust on surfaces in mines and selected industries facing a potential fire/explosion risk. It has never been utilized as a measure of inhalation risk. The reasons for its past usage and the rejection of settled dust as a metric for inhalation risk will be discussed in this report.

There are potentially toxic agents in the occupational setting and the environment where sampling for settled dust is meaningful for evaluation of health hazard and risk. When the particulate agent exhibits solubility in body fluids, entry to the body via the gastrointestinal tract or the skin can lead to solubility in the blood, systemic circulation and deposition/storage in a critical body organ. Sampling for surface dust indicates if finger and hand contamination with subsequent mouth insertion or food contamination followed by ingestion is possible and potentially significant. For this reason settled dust is sampled for evaluation of the potential hazard of soluble Lead, Cadmium, Chromium and Mercury – all systemic heavy metals and potentially toxic agents, for examples. Settled dust sampling is also used to assess the potential health hazard of liquid Polychlorinated Biphenyls (PCB's) which can be absorbed through the skin.

Asbestos is not a systemic poison. It is an inhalation hazard. Settled dust is not useful to assess the inhalation hazard from asbestos. It should be noted that settled dust is not used to assess the inhalation hazard from other potentially lung damaging dusts, including coal dust, cotton dust and silica dust. There are U.S. Federal standards of the Occupational Safety and Health Administration and the Mine Safety and Health Administration for coal dust, cotton dust, silica dust and asbestos dust that rely exclusively on air sampling to assess inhalation hazard. These agencies do not use settled dust measurements to assess the inhalation risk of potentially toxic agents, including asbestos, in the occupational environment. The Environmental Protection Agency (EPA) uses air sampling, not settled dust measurements, to determine the adherence of airborne concentrations of community air quality criteria pollutants to their respective standards. This includes a standard for particulate matter in air.

## III. Particle Size Distribution of Suspended Particles and Settled Dust

Particle sizes less than ten microns Aerodynamic Equivalent Diameter (AED)* can penetrate the defenses of the human upper respiratory tract and enter the non-ciliated portion of the airways. Particles that can penetrate the airways in this way to deposit in the lungs are less than 10 microns AED (1 micron = $10^{-4}$ centimeter). The fraction of airborne particles that penetrate in this way is known as respirable particles and they comprise the respirable portion of airborne particles (1,2). For reference, the unaided human eye can see a 50 micron particle. Thus, respirable particles are not visible to the human eye. Under certain circumstances, particles not visible to the eye can scatter light,

*The AED is the size of a spherical particle of density one gram per cubic centimeter that settles in air at the same velocity of the particle stream, where it will be transported by the air (10). For particles of respirable size a velocity of approximately 10 meters/sec (approximately 39 feet per second, or 2340 feet per minute is required (11)). Room air velocities rarely exceed 50 fpm because average room air velocities in excess of 25 feet per minute can cause occupant sensations of chilling.

in which case the observer sees the scattered light, not the particles.

Respirable particles in air move with air currents and tend to be removed from air by mechanisms of impaction and interception with other surfaces, electrostatic deposition and very slow settling. When settling occurs, it is far less significant than with larger particles visible to the eye. Thus, in still air a 10 micron unit density sphere (the largest size to penetrate to the lungs) settles in air at a rate of 0.29 cm/sec; approximately a 50 micron unit density sphere settles at 7.3 cm/sec (2). Air in rooms and factories is not still. A typical room air current is 7.6 cm/sec (15 feet per minute). Thus, visible particles and some larger than respirable size but not visible are more likely to reach the ground and be removed by settling. Confirmation of these phenomena is offered by the small percentage of settled dust particles that are respirable.

## IV. Redispersion or Re-entrainment of Settled Dust on Surfaces

Micron size particles that have settled on solid surfaces in air are submerged in a viscous fluid layer (4,5). This is often referred to as the boundary layer because the transition of fluid velocity from zero at the surface to the beginning of turbulence in the air moving past the surface, occurs in this layer. For a particle to break free of the surface and become airborne the lift velocity of the air stream must overcome the forces of adhesion between the particle and the surface (Van der Waals forces), and viscous forces between the particle and the fluid (viscous forces). I measured these forces to fulfill the requirements of the Doctor of Philosophy degree and during subsequent Federally supported grant research. The forces are formidable for particles to overcome, especially respirable size particles submerged in the boundary layer (6,7,8,9). Energy is required to dislodge a particle from the adhesive bond and to project it through the viscous boundary layer to the turbulent air.

Larger particles, such as beach sand particles which average 80 microns in size, project part of their cross section through the viscous boundary layer into the turbulent air stream and can be made airborne at lower air velocities than are required for respirable particles (12). Thus the phenomenon of shifting desert dunes and beach sand.

## V. Composition of Dust as a Function of Particle Size

Because of the differential settling of different size particles in air, as discussed above, the particle size distribution of settled dust differs from those of the respirable dust particles suspended in air. The chemical composition of dusts varies with their particle size, as demonstrated at an early date by Drinker and Hatch (13) for industrial dust. Air pollution data for suspended particulate matter and for settled dust ("dustfall") also indicate chemical composition differences in these two types of samples (14).

## VI. Is Settled Dust Assessment Relevant to Assessing Asbestos Inhalation Risk?

Because of the nature of settled dust and the difficulty of re-entraining particles of a size that can penetrate to the human lung after inhalation, settled dust has never been utilized by public health or occupational health professionals to determine whether or not an inhalation risk exists from insoluble respirable dust in air. Asbestos-in-air is classified as an insoluble dust because all forms of the mineral are sparingly soluble in body fluids or water. Instead of using an indirect method, such as settled dust, to work backwards to infer what particles exist suspended in air, all methodologies for assessing asbestos-in-air inhalation risk at work and in the community rely on instruments that obtain a sample of airborne, as contrasted to settled particles.

Thus, the Occupational Safety and Health Administration (OSHA) relies upon a method that has the worker wear a sampling pump that draws a sample of air from the breathing zone through a filter worn on the lapel. The filter is subsequently analyzed for asbestos content by a Certified Laboratory. The amount of asbestos-in-the-air, expressed as fibers of a given size per cubic centimeter of air can be calculated from the results of microscopic analysis of the sample and the amount of air drawn through the filter and pump. The methodology was developed by the National Institute of Occupational Safety and Health (NIOSH) and is included as an appendix to the standard (15). The standard was lowered and the sampling methodology received minor improvements in 1994, but the basic methodology of sampling asbestos fibers in air remained unchanged (16). Settled dust measurements are not used by OSHA to assess inhalation risk.

The U.S. Environmental Protection Agency (EPA) utilizes an air sampling methodology to measure asbestos-in-air to determine if occupants of a building can reenter the premises after completion of an asbestos abatement. The criterion for reentry is 0.01 fibers per cubic centimeter. The agency utilizes a laboratory analytical procedure that differs from that of OSHA, but collection of the airborne sampler on a filter, with a higher air flow rate, is similar to the methodology of OSHA. Thus, EPA does not use settled dust to assess inhalation risk to occupants upon reentry to a building after remediation/removal of asbestos.

The American Conference of Governmental Hygienists (ACGIH) issues annual guidelines for permissible concentrations of potentially toxic substances in air, including asbestos and has been issuing such guidelines for more than fifty years. They are known as Threshold Limit Values, or TLV's (as contrasted to OSHA's Permissible Exposure Limits, or PEL's). There are TLV's for approximately 800 substances (17). All require air sampling. ACGIH does not utilize settled dust as a measure of inhalation risk.

Thus, to the best of my knowledge, settled dust is not used by any governmental agency to measure inhalation risk in the U.S. and is not the basis for an inhalation risk standard in any nation in the world. Nor is it embodied in any standard or guideline by any professional organization for the purpose of measuring inhalation risk.

In a major review of asbestos in public and commercial buildings in the U.S. performed in response to the public concern for the health of building occupants and maintenance

workers, only the results of measurements of asbestos-in-air were reviewed prior to commenting on health risk; settled dust measurements were not considered (18).

In summary, scientific theory and investigations demonstrate that settled dust measurements are not relevant to assessing the health risk of airborne asbestos.

## VII. Settled Dust in Buildings

Settled dust measurements appeared in the courtroom in the 1980's in asbestos-in-buildings litigation. The rationale by plaintiff's experts was that they provided evidence for building "contamination" by asbestos in-place products, such as above ceiling pipe lagging or structural steel sprayed on materials. The results of these measurements were used to suggest that disturbance of the settled dust during routine maintenance or housekeeping could create an inhalation hazard to building occupants and that removal of the asbestos containing material was necessary. In other words, the measurements of settled dust were alleged to represent a history of past exposure and the potential for future exposure from reentrained respirable asbestos fibers. Measurements of settled dust during this time period exhibited large variation due to the absence of a standardized procedure for obtaining a sample.

In order to standardize the sampling procedure the American Society for Testing Materials (ASTM) adopted a standard procedure and recommended its use by all concerned so that settled dust measurements could be meaningfully compared (19,20). Subsequent efforts in residential properties to evaluate whether any correlation exists between airborne concentrations of asbestos and asbestos concentrations measured in settled dust indicated that (21):

- The presence of asbestos in the surface dust is independent of the presence of asbestos in bulk samples collected from the residences.
- The presence of airborne asbestos is independent of the presence of asbestos in surface dust.
- Observing asbestos in a dust sample does not imply that asbestos will be found in an air sample nor does it imply that asbestos will be found at some predictable air concentration.

Another study, performed in the laboratory, to determine resuspension factors for respirable and non-respirable particles and fibers concluded that "simple resuspension factor calculations using surface dust measurements, made by either ASTM D5755-95* or D5756-95*, do not provide a valid scientific basis for prediction of airborne chrysotile concentrations" (22).

Thus, it is clear from data collected in the field and the laboratory that settled dust containing asbestos fibers cannot meaningfully be related to the presence or concentrations of respirable asbestos fibers in air and, therefore, to inhalation risk.

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*See references 19 & 20

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